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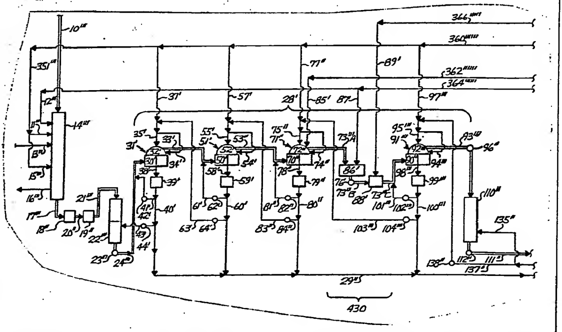

(57) Abstract

A wood pulp slurry (17, 73, 123, 209) is treated with oxygen (89, 429, 212) in a mill with little change to the process or structure of the mill. No special pressure tanks are required. The consistency of the pulp need not be altered for the treatment step. It may be treated at the usual process consistency of the pulp; e.g.; it may be treated at the usual consistency of the pulp leaving a washer or subsequent steam mixer (86, 426, 206) without additional dewatering or additional dilution. The oxygen is added into a closed section of the system so that it cannot immediately vent to the atmosphere. Alkali (85, 425, 207) should also be present when the oxygen is mixed with the slurry. The mixing (88, 428, 211) should occur near to the point of oxygen addition. The pulp is treated with oxygen several times during a sequence. Some sequences are O-X-O and O-O-X-O in which X may be a hypochlorite, a peroxide or ozone, or chlorine, chlorine dioxide, combinations of chlorine (438) and chlorine dioxide (471), hypochlorite, peroxide or ozone. The sequence may be followed by a D stage (232). Specific mixer designs are also disclosed.

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METHOD OF TREATING PULP WITH PLURAL OXYGEN STAGES

BACKGROUND OF THE INVENTION

1. Field of the Invention

Apparatus and process for treating wood pulp with oxygen.

2. Review of the Prior Art

The standard symbols for pulping and bleaching sequences are:

S = Sulfite
K = Kraft
So = Soda
C = Chlorine
H = Sodium or calcium hypochlorite
E = Alkali extraction, usually with sodium hydroxide
D = Chlorine dioxide
P = Alkaline peroxide
O = Oxygen
A = Acid pretreatment or post treatment

Consistency is the amount of pulp fiber in a slurry, expressed as a percentage of the total weight of the oven dry fiber and the solvent, usually water.

Low consistency is from 0-6%, usually between 3 and 5%.

Medium consistency is between 6 and 20%. Fifteen percent is a dividing point within the medium-consistency range. Below 15% the consistency can be obtained by filters. This is the consistency of the pulp mat leaving the vacuum drum filters. The consistency of a slurry from a washer, either a brownstock washer or a bleaching stage washer, is 9-13%.

High consistency is from 20-40%.

Fig. 1A-1C is a diagram of a typical pulp mill.

Chips 10, process water 11, steam 12 and pulping chemicals 13 are placed in a digester 14. The wood chips 10 may be treated prior to entering the digester 14. This is optional. Exemplary of such treatment are presteaming of the chips in a steaming vessel or impregnation of the chips with the digestion chemicals in an impregnation vessel prior to entering the digester. The chemicals 13 will depend on the process being used, be it sulfate, sulfite, or soda, and the digester 14 may either be batch or

continuous in operation. A continuous digester is shown. The chips will be cooked under appropriate conditions within the digester. These conditions, which depend on the species of chip and the type of pulping used, are well known.

The treatment of the chips, after cooking, will depend in part on the type of digester being used. In the continuous digester shown, the chips are washed in the washing section of the digester. This is indicated by process water 15 entering and effluent stream 16 leaving the washing stage of digester 14.

This washing would not take place in a batch digester. In a batch system, all the washing would occur in the following brownstock washing system.

Following this treatment, the chips will pass from the digester 14 through the blow line to storage or blow tank 22.

Tank 22 may be a diffusion washer instead of a storage tank.

In the present diagram, two refiners - 18 and 19 - are shown. The refiners are optional.

The blow line is shown in three sections - section 17 between the digester 14 and refiner 18; section 20 between the refiners 18 and 19; and section 21 between the refiner 19 and the storage tank 22.

From the storage tank 22 the fibers and liquor are carried by pump 23 through line 24 to the washers and screens.

The pulp slurry is first carried to the washers 28 where the rest of the lignin and chemicals are removed from the fibers. Four washers are shown. Each of these washers is usually a vacuum or pressure drum washer or filter and the operation of each is the same.

The pulp slurry from line 24 enters the vat 30 of washer 31. The vacuum drum 32 revolves through the vat, and the vacuum pulls the fibers in the slurry onto the outer surface of the filter drum and holds the fibers, in mat form, against the surface while pulling the liquor or filtrate through the filter cloth to the interior piping of the vacuum drum to be discharged as effluent. The revolving drum carries the fiber mat from the vat past a bank of washer heads that spray a weak filtrate onto the mat to displace the liquor from the mat. The vacuum also pulls this displaced liquid into the interior piping of the drum. The consistency of the mat leaving a washer, either the brownstock washers described here or the bleach washers described later, will usually be between 8 to 15%.

The pulp mat 33 is removed from the face of the drum 32 by a doctor blade, carrier wires or strings between the drum and the mat, rolls or any other standard manner and carried to the vat 50 of the second washer 51. The fibers are picked up on vacuum drum 52. The pulp mat 53 is carried to the vat 70 of washer 71. The vacuum drum is 72 and the mat 73. The mat 73 is carried to the vat 90 of the washer 91. The vacuum drum is 92 and the mat 93.

From the brownstock washers the pulp mat 93 is carried to storage tank 110 with the aid of thick stock pump 96. In the lower section of tank 110, the pulp is diluted and then carried through line 111 by pump 112 to screens 113 in which the larger fiber bundles and knots are removed. The bundles and knots 114 are carried to further treatment.

The pulp 115 is carried from the screens 113 to the vat 120 of decker 121 in which additional water is removed. The operation of the decker is similar to that of the washers. Washing showers may be used in the decker. The vacuum drum is 122 and the pulp mat is 123. The pulp 123 is carried by thick stock pump 126 to a high-density storage tank 140 in which it is stored until it is bleached.

The liquor or filtrate from the vat 120 and the mat 123 flows through piping which extends radially from the vacuum chambers at the surface of the vacuum drum 122 to a pipe in the central shaft of the rotating drum. This liquor or filtrate passes through the central pipe and an external line 128 to a filtrate storage tank or seal tank 129. The tank 129 is called both a storage tank and a seal tank because it acts both to store the filtrate for further use and to seal the vacuum drum 122 from the outside atmosphere to maintain the lower pressure of the vacuum system within the drum.

The following description is illustrative of how the effluent from any of the washers would be handled.

First, the filtrate from tank 129 is reused to reduce the consistency of the pulp slurry either entering the decker 121, entering the screens 113 or leaving storage tank 110. Line 130 carries the filtrate to lines 131, 133 and 135. Line 131 and pump 132 carry the filtrate back to screened pulp 115 to reduce the consistency of the pulp slurry entering vat 120 to around 1-1/2%. Line 133 and pump 134 carry the filtrate back to line 111 to reduce the consistency of the pulp slurry entering the screens 113 to from 0.2

to 2%. Line 135 and pump 136 carry the filtrate back to storage tank 110 to reduce the consistency of the pulp slurry leaving the tank to around 5%.

Second, the filtrate may be taken to an effluent treatment system by line 130 and effluent line 29.

Third, the filtrate may be used as wash water in the brownstock washing system 28. In this system, the filtrate flow is counter to the flow of pulp. The line 137 and pump 138 carry the filtrate back to washer 91 for use as wash water. The filtrate is sprayed on the pulp mat by washer heads 95. This filtrate may remove any pulp fibers that cling to the wires, strings or rolls if water instead of air is used for this operation. This is done by cleanup washer 94.

Additional water may be required to supplement the filtrate. This is provided through process water line 97.

In the flow of filtrate through washer 91, the liquor, either from the mat or the vat, is carried through internal piping to line 98 and seal tank 99. The filtrate may be handled in a number of ways. Line 100 would carry it to effluent line 29. Line 101 and pump 102 would carry the filtrate to pulp 73. Line 103 and pump 104 would carry the filtrate to washer 71 as wash water.

The process in brownstock washers 71, 51 and 31 are, for the most part, identical to the process in brownstock washer 91. The washer heads are 75, 55 and 35. The cleanup washers are 74, 54 and 34. The filtrate lines are 78, 58 and 38 and the seal tanks are 79, 59 and 39. The lines to effluent line 29 are 80, 60 and 40.

The lines and pumps carrying the filtrate to the pulp entering a vat are 81 and 82, 61 and 62, and 41 and 42. The counterflow wash water lines and pumps are 83 and 84, and 63 and 64.

In brownstock washer 31, line 43 and pump 44 carry the filtrate into storage tank 22.

Additional process water may be needed to supplement the filtrate being used as wash water. Lines 77, 57 and 37 are for this purpose. These lines would provide all the wash water to the individual washers if the counterflow system is not used.

The washed pulp remains in storage tank 140 until it is carried into the bleaching system.

The particular bleaching sequence illustrated is D_CEDED.

The pulp stored in high-density tank 140 normally is at a consistency of approximately 9 to 15%. This pulp slurry is carried from tank 140 through line 141 to tank 146 by pump 142. The pulp in line 141 is diluted with additional water or filtrate to a consistency of around 5%. In mixer 144 in line 141, the slurry is mixed with chlorine dioxide from line 145 as the D step of the first stage D_C bleach. The treated dilute slurry enters storage tank 146 in which the chlorine dioxide reacts with the unbleached pulp. The time of this initial treatment normally is one to five minutes. The slurry exits the tank into line 150 and is treated with chlorine.

Chlorine from line 151 and process water from line 152 are mixed in aspirator 153 and the diluted chlorine flows through line 154 to mixer 155 in which the chlorine is mixed with the dilute pulp slurry in line 150. The treated slurry is moved by pump 156 through line 150B into chlorine bleaching tower 157. The treated slurry exits tank 157 and is carried through line 158 by pump 159.

The slurry in line 158 is combined with additional water or filtrate to reduce the consistency to about 1 to 1-1/2%. This dilute slurry flows into vat 160 of washer 161. Again a vacuum drum washer or filter is shown. The operation of this washer is the same as that of the brownstock washers.

The pulp mat 163 is removed from the face of drum 162. The pulp mat 163 is moved to mixer 166.

Prior to leaving washer 161, the pulp mat 163 is impregnated with the caustic or alkali extraction solution from line 167. A sodium hydroxide solution is usually used. The amount of alkali added, expressed as sodium hydroxide, will be 0.5 to 7% of the oven-dry weight of the pulp. The alkali may be added to the pulp in the steam mixer 166 instead of at the washer 161.

In steam mixer 166 the treated mat is mixed with steam from line 168 to raise the temperature of the pulp to approximately 62^{o}C. The heated slurry is carried through line 169 into extraction tower 173 by high-density pump 170. The slurry remains in tower 173 to allow the extraction solution to react with and extract the chlorinated materials from the pulp. This time may be one to two hours.

Before leaving the extraction tower, the pulp slurry is mixed with water or filtrate in dilution zone 174 to reduce its consistency to

approximately 5%. The slurry is carried by line 175 and pump 176 from dilution zone 174 to the vat 180 of washer 181. Washer 181 is shown and described as a vacuum or pressure drum washer but it may be a diffusion washer. During its passage through line 175, the slurry is further diluted with water or filtrate until its consistency is approximately 1 to 1-1/2% when it reaches the vat 180. The operation of washer 181 is identical to that of washer 161. The fibers are picked up on the revolving drum 182, washed and removed as pulp mat 183.

The pulp is then moved to steam mixer 186 of the chlorine dioxide stage. Prior to leaving washer 181, the mat 183 is treated with a slight amount of alkali from line 187. A sodium hydroxide solution is usually used. The purpose of this treatment is adjustment of the pH of the pulp prior to being treated with chlorine dioxide. The alkali may be added in the steam mixer 186 instead of the washer 181.

In steam mixer 186 the pulp 183 is mixed with steam from line 188.

The pulp leaves steam mixer 186 and is carried through line 189 by pump 190 to mixer 191 in which it is combined with chlorine dioxide from line 192. It then enters chlorine dioxide tower 193. The retention time in the tower is usually four hours. Prior to leaving the tower, the slurry is diluted to a consistency of about 5% in dilution zone 194. It is also treated with a small amount of sulfur dioxide or alkali from line 197. The sulfur dioxide or alkali reacts with any excess chlorine dioxide.

This diluted slurry is then carried by line 195 and pump 196 to vat 200 of washer 201. During its passage through line 195, the slurry is again diluted and treated with additional sulfur dioxide from line 198. The pulp is picked up on vacuum drum 202, and removed as pulp mat 203.

This pulp is moved to the steam mixer 206 of the second extraction stage. Sodium hydroxide from line 207 is added on washer 201 or at the mixer 206, and in mixer 206 the treated pulp mat 203 is mixed with steam from line 208. This slurry is then carried through line 209 by pump 210 to extraction tower 213. The conditions in the extraction stage are the same.

The pulp enters dilution zone 214, and its consistency is reduced to approximately 5%. The pulp is carried through line 215 by pump 216 to the vat 220 of washer 221. Washer 221 is shown and described as a vacuum

or pressure drum washer but may be a diffusion washer. The slurry is picked up by vacuum drum 222 and discharged as pulp mat 223. The pH of the pulp may be adjusted by treating the mat with sodium hydroxide from line 227. This may occur on the drum 222 or in the steam mixer 226.

The pulp enters the last chlorine dioxide stage. The conditions are the same as in the first chlorine dioxide stage. The pulp is carried to steam mixer 226, mixed with steam from line 228, carried through line 229 by pump 230 to mixer 231, mixed with chlorine dioxide from line 232 and carried into the chlorine dioxide tower 233 where it remains for one to four hours. The pulp then enters dilution zone 234 and is treated with a small amount of sulfur dioxide from line 237 to remove any excess chlorine dioxide.

The slurry is carried through line 235 by pump 236. During its travel, the pulp is treated with additional sulfur dioxide or alkali from line 238 to remove any free chlorine dioxide and is further diluted so that the slurry is at a consistency of about 1 to 1-1/2% when it reaches vat 240 of washer 241. It is picked up by vacuum drum 242 and discharged as bleached pulp 243.

The cleanup washers are 164, 184, 204, 224 and 244. Air may also be used.

The passage of liquid through the washer is the same as in the brownstock washers.

In washer 161, the washer heads are 251, the external line is 252 and the seal or storage tank is 253. In washer 181, the washer heads are 271, the external line is 272 and the seal or storage tank is 273. In washer 201, the washer heads are 291, the external line is 292, and the seal or storage tank is 293. In washer 221, the washer heads are 311, the external line is 312, and the seal or storage tank is 313, and in washer 241 the washer heads are 331, the external line is 332, and the seal or storage tank is 333.

The routes taken by the filtrate after it leaves the seal or storage tank are also the same as those in the brownstock washers.

The filtrate from the seal tank 253 would be carried by line 255 and pump 256 into line 158. Line 275 and pump 276, and line 277 and pump 278, carry the filtrate from the seal tank 273 into line 175; line 295 and pump 296, and line 297 and pump 298, carry the filtrate from the seal tank 293 into line 195; line 315 and pump 316, and line 317 and pump 318, carry the

filtrate from the seal tank 313 into line 215; and line 335 and pump 336, and line 337 and pump 338, carry the filtrate from the seal tank 333 into line 235.

In the chlorine stage, line 259 and pump 260 also carry the filtrate to line 141.

The filtrate from seal tank 273 is carried into the dilution zone 174 by line 281 and pump 282. Line 301 and pump 302 carry the filtrate from the seal tank 293 into the dilution zone 194. Line 321 and pump 322 carry the filtrate from the seal tank 313 into dilution zone 214, and line 341 and pump 342 carry the effluent from the seal tank 333 into dilution zone 234.

The filtrate is discharged as effluent by lines 254, 274, 294, 314, and 334. The effluent from the chlorine stage washer 161 is separate from the effluent from the other washers. The other lines discharge into effluent line 350.

In the counterflow washing system shown, the wash water for washer 241 is process water from line 330; for washer 221 is filtrate from washer 241 supplied by line 343 and pump 344; for washer 201 is filtrate from washer 221 supplied by line 323 and pump 324; for washer 181 is filtrate from washer 201 supplied by line 303 and pump 304; and for washer 161 is filtrate from washer 181 supplied by line 283 and pump 284. Any additional wash water would be supplied through lines 250, 270, 290 and 310. These lines would provide all the wash water to the individual washers if the counterflow system is not used.

The chemical, water and steam supplies to the system are shown in the upper section of Fig. 1. Process water is carried through line 360 to the various lines supplying water, line 351 to the digester, lines 37, 57, 77 and 97 to the brownstock washers 28, line 152 to the chlorine aspirator 153, and lines 250, 270, 290, 310 and 330 to the bleach system washers. Chlorine is supplied through line 361 to line 151. Alkali line 362 supplies dilute alkali to lines 167, 187, 207 and 227. Chlorine dioxide line 363 supplies a chlorine dioxide solution to lines 145, 192 and 232. Steam is supplied through line 364 to steam lines 12, 168, 188, 208 and 228. Sulfur dioxide is supplied to lines 197, 198, 237 and 238 from line 365.

There are two principal types of measurements to determine the completeness of the pulping or bleaching process, the degree of delignification and the brightness of the pulp. There appears to be no correlation

between the two because the delignification factor is a measure of residual lignin within the pulp and the brightness is a measure of reflectivity of the pulp sheet.

There are many methods of measuring the degree of delignification of the pulp but most are variations of the permanganate test.

The normal permanganate test provides a permanganate or K number - the number of cubic centimeters of tenth normal potassium permanganate solution consumed by one gram of oven dry pulp under specified conditions. It is determined by TAPPI Standard Test T-214.

The Kappa number is similar to the permanganate number but is measured under carefully controlled conditions and corrected to be the equivalent of a 50% consumption of the permanganate solution in contact with the specimen. The test gives the degree of delignification of pulps through a wider range of delignification than does the permanganate number. It is determined by TAPPI Standard Test T-236.

PBC is also a permanganate test. The test is as follows:

1. Slurry about 5 hand-squeezed grams of pulp stock in a 600-milliliter beaker and remove all shives.

2. Form a hand sheet in a 12.5-centimeter Buckner funnel, washing with an additional 500 milliliters of water. Remove the filter paper from the pulp.

3. Dry the hand sheet for 5 minutes at 99 to 104°C.

4. Remove the hand sheet and weigh 0.426 grams of it. The operation should be done in a constant time of about 45 seconds to ensure the moisture will be constant, since the dry pulp absorbs more moisture.

5. Slurry the weighed pulp sample in a 1-liter beaker containing 700 milliliters of 25°C tap water.

6. Add 25 milliliters of 4 N sulphuric acid and then 25 milliliters of 0.1000 N potassium permanganate. Start the timer at the start of the permanganate addition.

7. Stop the reaction after exactly 5 minutes by adding 10 milliliters of the 5% potassium iodide solution.

8. Titrate with 0.1000 N sodium thiosulfate. Add a starch indicator near the end of the titration when the solution becomes straw color. The end point is when the blue color disappears.

In running the test, the thiosulfate should first be added as rapidly as possible to prevent the liberation of free iodine. During the final

part of the titration the thiosulfate is added a drop at a time until the blue color just disappears. The titration should be completed as rapidly as possible to prevent reversion of the solution from occurring.

The PBC number represents the pounds of chlorine needed to completely bleach one hundred pounds of air dried pulp at 20°C in a single theoretical bleaching stage and is equal to the number of milliliters of potassium permanganate consumed as determined by subtracting the number of milliliters of thiosulfate consumed from the number of milliliters of potassium permanganate added.

Many variables affect the test, but the most important are the sample weight, the reaction temperature and the reaction time.

Jamieson "The Present and Future Role of Oxygen Bleaching," undated, discloses a number of sequences using oxygen. These include C_DOD, COD, OCED, OC_DOD, ODEDED and OC_DEDED.

Rerolle et al. U.S. Patent No. 3,423,282 describe sequences having a central OC sequence. These are OCE, OCP and $OCH_{(in\ situ)}$.

Smith et al. U.S. Patent No. 3,725,194 notes O_2CEDED, SO_2-O_2-SO_2-DED, So_2-O_2-H-DED, and SO_2-O_2-DED sequences.

Grigorescu "Oxygen Bleaching of Fibrous Pulps" Celuloza Si Hirtie <u>23</u> (2), 58-62 (1974) describes AODED, COD, CODED and OCDED sequences.

Jamieson et al. "Mill Scale Applications of Oxygen Bleaching in Scandinavia" 1973 TAPPI Alkaline Bleaching Pulping Conference, 231-238, lists a number of sequences. These are O, OP, OH, OD, ODED, COD, OCED, OC/DED, CODED, OC/DEHD, OCEDED, OC/DEDED, OHD, OPHD, OHPD, OC/DPD, OC/DE_HD, and OC.

Jamieson et al. "Advances in Oxygen Bleaching" TAPPI, 11/71, <u>54</u>, No. 11, 1903-1908 compares OC and CO sequences.

Soteland "Bleaching of Chemical Pulp with Oxygen and Ozone," <u>Pulp and Paper Magazine of Canada</u>, Vol. 75, No. 4, April 1974, pp. 91-96 mentions a number of sequences which include oxygen and high-consistency ozone treatments. These are oxygen-ozone, oxygen-ozone-peroxide, oxygen-ozone-hypochlorite, oxygen-ozone-ozone-peroxide, and oxygen-ozone-ozone-hypochlorite.

Rothenburg, et al. "Bleaching of Oxygen Pulps with Ozone," TAPPI, Vol. 58, No. 8, August 1975, pp. 182-185 describes oxygen-ozone,

oxygen-ozone-sodium hydroxide extraction -ozone, oxygen-ozone-peroxide and oxygen-ozone-acetic acid sequences. The ozone treatment is high consistency in each of these sequences.

Kirk et al. "Low Consistency Oxygen Delignification in a Pipeline Reactor - Pilot Study," 1977 TAPPI Alkaline Pulping/Secondary Fibers Conference, Washington, D.C., November 7-10, 1977, describes a pipeline reactor.

SUMMARY OF THE INVENTION

The usual oxygen systems require a capital investment of several million dollars because of the large vessels employed. The high-consistency systems require complex machinery to fluff the pulp prior to oxygen treatment. It limits the oxygen treatment to a single stage.

The inventors decided to investigate both the need for costly expenditures and for lengthy times in which to do oxygen bleaching. They decided to add oxygen to an existing system and determine the results. They found, contrary to prior art teaching, that the oxygen may be added to the pulp and processed at the consistency at which the pulp normally comes from the washer or subsequent steam mixer, that much of the treatment occurs in less than a minute in the mixer and that a long reaction time or large capital-intensive equipment is not required for oxygen treatment. What is required is relatively small mixing equipment which intensively mixes the pulp and the gas.

Several desirable treatment sequences are possible. These are O-X-O and O-O-X-O in which X is a hypochlorite, a peroxide or ozone. The sequence may be followed by a D step.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 (A-C) is a diagram of a prior art pulping and bleaching process.

Fig. 2 is a diagram of a prior art oxygen bleaching system.

Fig. 3 is a diagram of the present oxygen bleaching system.

Fig. 4 is a diagram of the present oxygen system in an extraction stage.

Fig. 5 is a diagram of the present oxygen system between washers.

Fig. 6 is a diagram of the present oxygen system between a washer and storage.

Fig. 7 (A-C) is a diagram of a pulping and bleaching process using the oxygen bleaching systems of Figs. 3 and 4, and a modification of Fig. 6.

Fig. 8 (A-C) is a diagram of a pulping and bleaching process using the oxygen bleaching system of Fig. 6, and a modification of Fig. 6.

Fig. 9 is an isometric view of a mixer that may be used in the present invention.

Fig. 10 is a side plan view of the mixer shown in Fig. 9.

Fig. 11 is a cross section of the mixer taken along line 11-11 of Fig. 10.

Fig. 12 is a cross section of the mixer taken along line 12-12 of Fig. 11.

Fig. 13 is a plan view of a rotor.

Fig. 14 is a cross section of the rotor taken along line 14-14 of Fig. 13.

Fig. 15 is a plan view, partially in cross section, of a modified rotor.

Fig. 16 is a cross section of the modified rotor taken along line 16-16 of Fig. 15.

Fig. 17 is a plan view, partially in cross section, of a stator which may be used with the mixer.

Fig. 18 is a side plan view, partially in cross section, of a modified stator taken along a line corresponding to line 18-18 of Fig. 17.

Fig. 19 is a cross section of the stator taken along line 19-19 of Fig. 17.

Fig. 20 is a cross section of a valve taken along line 20-20 of Fig. 18.

Fig. 21 is an isometric view of a modified mixer.

Fig. 22 is a side plan view of the mixer of Fig. 21.

Fig. 23 is a cross section of the mixer taken along line 23-23 of Fig. 22.

Fig. 24 is a cross section of the mixer taken along line 24-24 of Fig. 23.

Fig. 25 is a cross section of a rotor used in the reactor of Figs. 21-24.

Fig. 26 is a cross section of the rotor taken along line 26-26 of Fig. 25.

Fig. 27 is a graph comparing two mixers.

Fig. 28 is a cross section of a modified mixer.

Fig. 29 is a cross section of the modified mixer taken along line 29-29 of Fig. 28.

Fig. 30 is an enlarged cross section of the interior of the mixer shown in Fig. 28.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Figs. 2 and 3 compare the size and complexity of a prior art oxygen bleaching system of the type shown in Verreyne et al. U.S. Patent No. 3,660,225 with the present system. Both drawings are to the same scale. Both units would handle the same amount of pulp in an oven-dry weight basis.

In the prior art system shown in Fig. 2, pulp 400 from mill 401 is carried by pump 402 to a storage tank 403. In storage tank 403 the pulp is mixed with an alkali solution 404 from filtrate storage tank 405. A protector would be added to the pulp at this time also. The treated pulp mixture 406 is moved by pump 407 to a dewatering press 408 which removes enough water from the pulp to raise the consistency of the pulp slurry to around 20-30%. This material is then carried by pump 409 to the top of the oxygen reactor. The pump 409 is a series of screw conveyers, the only way to pressurize pulp of this consistency. At the top of the reactor 410 is a fluffer 411 which spreads the pulp uniformly over the top tray 412 of the reactor. The pulp passes down through the other trays 413-416 and is treated with oxygen during its passage through the trays. From the bottom of the trays the bleached pulp 417 is carried to storage tank 418.

This mill should be contrasted to the present system shown in Fig. 3. The mixing tank 403, filtrate storage tank 405, press 408, pump 409, and reactor 410 have been replaced by a simple mixer 420 in which the oxygen is mixed with the pulp 400'.

By comparison, the system of Fig. 2 requires a power six times as large as the mixer or system of Fig. 3. For the same quantity of pulp, the system of Fig. 2 would require an aggregate of 2238 kW in motors to operate the reactor and the various pieces of equipment associated with the reactor, while the mixer of Fig. 3 would require a 373 kW motor.

The mixer of Fig. 3 is also able to operate at consistencies usually found in pulping and bleaching systems. This would usually be the

consistency of pulp leaving the washer or the subsequent steam mixer, a consistency of around 8 to 15% from the washer and around 1% less for the steam mixer.

Fig. 4 shows the oxygen mixer in a standard caustic extraction stage of a bleaching system. It shows that a simple change can turn a caustic extraction stage into an oxygen treatment stage. To allow comparison of this extraction stage with the same one in Fig. 1, the same reference numerals have been used. The operation of the various pieces of equipment - the washers 201' and 221', the steam mixer 206', the extraction tower 213' and the seal tanks 293' and 313' - are the same as in the prior art extraction stage in Fig. 1.

The flows of pulp and wash water through the system are also the same as in Fig. 1.

The pulp 195' enters washer 201' where it is washed, dewatered and treated with alkali, usually sodium hydroxide. The consistency of the pulp leaving the washer is usually in the range of 8 to 15%. The exiting pulp 203' then is mixed with the alkali and steam in steam mixer 206'. Pulp consistency is reduced about 1% in the steam mixer. From the steam mixer the pulp goes to extraction tower 213' where it remains for the usual period of time. It is diluted and carried to washer 221', where it is washed and dewatered.

Although washer 221' may be a diffusion washer, it is shown and described as a vacuum or pressure drum washer.

In washer 221' the water is either fresh process water through line 310', counterflow filtrate through line 343' or a combination of these, and in washer 201' the wash water is either fresh process water through line 290', or counterflow filtrate through line 323', or a combination of these.

The filtrate from washer 201' is stored in seal tank 293' and is used as dilution water through lines 295', 297' and 301', as wash water through line 303', or sent to effluent treatment through line 294'. It is shown being treated separately from effluent in line 350' because the effluent, if from a chlorine stage, would be treated separately from effluent from an oxygen stage.

Similarly, the filtrate from washer 221' is stored in seal tank 313' and used as dilution water through lines 315', 317' and 321', as wash water through line 323', or treated as effluent through line 314'. Since the oxygen

effluent has little, if any, chlorine components, it may be combined with the effluent from the brownstock washers and the digester and be treated in the recovery furnace thus reducing the amount of material that must be sewered to an adjacent stream or body of water.

The supply lines are 360''' for process water, 362''' for sodium hydroxide solution, and 364''' for steam.

The description of the stage so far is, with the exception of splitting the effluent stream, identical to the description of the extraction stage in Fig. 1. Only one minor change is required to turn this extraction stage into an oxygen stage. That is the addition of the oxygen mixer 211 into line 209', of the oxygen line 212 to either the mixer 211 or the line 209'A just in front of the mixer and of the oxygen supply line 366''. The pulp leaves steam mixer 206' through line 209'A and enters the oxygen mixer 211 and the oxygenated pulp leaves the mixer 211 through line 209'B and enters the extraction tower 213'. The amount of oxygen supplied to the pulp would be 11 to 28 kilograms per metric ton of oven-dry pulp. A preferred range is 17 to 22 kilograms of oxygen per metric ton of oven-dry pulp.

All conditions - time, temperature, pressure, consistency, pH and chemical addition - may remain about the same as they were in the extraction stage shown in Fig 1. The temperature would normally be increased from 71-77°C for an extraction stage to 82-88°C for an oxygen treatment stage, because the treatment is improved at higher temperatures. Again, the temperature may be as high as 121°C. The amount of alkali, expressed as sodium hydroxide, is 0.5 to 7% of the weight of the oven-dry pulp. Channeling of the oxygen after mixing is of no particular consequence. If the extraction tower was a downflow tower, it remains a downflow tower. The physical location of mixer 211 is a matter of convenience, the simplicity of installation and maintenance being the sole criteria. If it can be placed in an existing line, it will be. If convenience requires that it be placed on the floor of the bleach plant, it will be placed on the floor of the bleach plant and an external pipe can carry the pulp slurry to the top of the extraction tower 213'.

The mixing produces an intimate contact between the gas and the slurry, and appears to divide the gas into mostly small bubbles. There may be some larger bubbles and gas pockets, however. The presence of some large bubbles and gas pockets up to the size of the pipe through which

the pulp slurry was passing have been observed. These have not affected the quality of the pulp or the treatment of the pulp.

There should be a back pressure on the pulp in the mixer. This may be provided by an upflow line after the mixer which creates a hydrostatic head at the mixer. A pressure valve is preferred. The valve may be combined with the upflow line. The valve may be placed in the line 209'B downstream of the mixer 211. The valve may be either right after the mixer or at the top of the line before the outlet.

The maximum pressure in the mixer would normally not exceed 830 kPa gage, and the top of the pipe would normally not exceed 345 kPa gage.

In a mill trial of the system, sampling was done at D, E and F. At point E, sampling was at the top of the tower 213' rather than directly after the mixer 211 because it was not possible to sample after the mixer. It required about 1 minute for the slurry to reach point E from the mixer. In these tests the mixer was on the bleach plant floor and an external line carried the slurry to the top of the tower.

Table I

PBC

D	E	F
1.4	1.13	0.95
1.41	1.13	0.90

Fig. 5 shows the oxygen mixer between two washers. In this case the washers are brownstock washers. Again, the reference numerals are the same as those found in Fig. 1 and the conditions in these two washers are the same as those noted in Fig. 1.

The differences between this unit and that in Fig. 1 are the addition of steam mixer 86, pump 76, mixer 88, and lines 85, 87 and 89. Line 85 adds alkali onto the mat 73'A as it is leaving the washer 71'. The amount of alkali, expressed as sodium hydroxide, placed on the mat is between 0.1 and 6%, preferably between 2 and 4%, based on the oven-dry weight of the pulp. The treated mat 73'A is then carried to steam mixer 86 in which it is mixed with the alkali and with steam from line 87 to increase the temperature of the pulp to 65-88°C and possibly as high as 121°C. From mixer steam 86 the pulp slurry 73'B is carried by a pump 76 to a mixer

88 in which it is mixed with oxygen from line 89. The amount of oxygen added will depend upon the K number of the pulp and the desired result. This will normally range from 5 to 50 kilograms per metric ton of oven-dry pulp. Two standard ranges for bleaching in a brownstock system are 22 to 28 and 8 to 17 kilograms of oxygen per metric ton of oven-dry pulp. The latter is a preferred range. The oxygenated pulp 73'C then passes to the vat 90' of washer 91'.

The washer after the mixer may be a diffusion washer.

Again there should be a back pressure on the mixer. This pressure is provided in the same way that the pressure is provided to mixer 211, by an upflow line, a pressure valve or a combination of these. The placement of the valve and the maximum pressure are the same as those for mixer 211.

Fig. 6 discloses a system placed between a washer such as brownstock washer 91" and a storage tank such as storage tank 110'. The reference numerals are same as those used in Fig. 1. The changes are the addition of steam mixer 106, mixer 108, alkali line 105 and its supply line 362"", steam line 107 and its supply line 364"", and oxygen line 109 and its supply line 366'"'. The amount of alkali and oxygen added to the pulp, the temperature of the pulp, and the time between alkali addition and oxygen addition and the pressure at the mixer and in the outlet line and the methods of obtaining these pressures are the same as in the system of Fig. 5. The other operating conditions would remain the same as in Fig. 1.

In each of these systems, the time between alkali addition and oxygen addition is usually from 1 to 5 minutes. The exact time will depend upon equipment placement and pulp speed.

A mill trial was run using the system shown in Fig. 6. In this system, the mixer 108 was floor mounted and the pipe 93"C carried the slurry from mixer 108 to the top of tower 110'. The tower was open to the atmosphere. A partially closed valve near the outlet of pipe 93"C created a 276 kPa gage back pressure in the line. The hydrostatic pressure in the line was 241.5 kPa gage, so the pressure within the mixer was 517.5 kPa gage.

Four trial runs were made under slightly different conditions to determine both the overall delignification effect of the system and the percentage of delignification taking place within each section of the system. K number measurements were taken before and after mixer 108, at the

outlet of pipe 93"C, at the outlet of tank 110', and at the outlet of the decker 121' (Fig. 7b) downstream of the tank 110'.

In a control run in which no oxygen was added to the system, it was determined that the K number was reduced by 1 number between the inlet of mixer 108 and the outlet of decker 121'. This probably was due to screening. In the overall delignification computation, the numbers were corrected for this 1 K number drop.

The various K numbers were taken within the system to determine the percentage of the total delignification or K number reduction taking place through the mixer 108, through pipe 93"C, through tank 110', and through decker 121'. Washer showers had been added to the decker for these tests. The slurry required between 10 to 15 seconds to pass through mixer 108, 2-1/2 to 3-1/2 minutes through pipe 93"C, and 1/2 to 3 hours through tank 110' or decker 121'. It was determined that in these tests, 30% of the total delignification occurred in mixer 108, 40% occurred in pipe 93"C, 8% occurred in tank 110', and 21% occurred between the tank and the decker. This latter reduction is caused by screening of the pulp.

Table II gives the actual conditions in the mixer: the temperature in degrees C; the kilograms of caustic, expressed as sodium hydroxide, and oxygen per oven-dry metric ton of pulp; the pressure in kilopascals gage; the K numbers at the various locations within the system; and the percent K number reduction. In Run No. 1, the percent reduction at the decker outlet in the last line is the reduction between the tip of the pipe and the decker outlet.

TABLE II

	Runs 1	2	3	4
Mixer Conditions				
Temp. °C	79.5	82	93	88
Caustic, kg/O.D.t.	15.1	20.2	15.1	20.2
Oxygen, kg/O.D.t.	22.7	25.2	20.2	25.2
Pressure, kPa gage	517.5	517.5	517.5	517.5
Overall Delignification				
Before Mixer				
K No.	19.6	25.4	19.9	24.1
K No. Corrected	18.6	24.4	18.9	23.1
After Decker				
K No.	15.6	19.2	15.1	17.8
% K No. Reduction	16	21	20	23
Delignification Within System				
Mixer Inlet				
K No.	19.6	25.4	19.9	24.1
Mixer Outlet				
K No.	18.5	23.3	18.6	21.3
% of Total Reduction	25	34	27	29
Top of Pipe				
K No.	16.8	21.5	16.0	19.8
% of Total Reduction	44	29	54	40
Tank Outlet				
K No.	-	20.5	16.0	19.3
% of Total Reduction	-	16	0	8
Decker Outlet				
K No.	15.6	19.2	15.1	17.8
% of Total Reduction	31	21	19	23

This data indicates that in any of the systems described in this application, a valve should be placed in the line downstream of the oxygen mixer to provide back pressure on the mixer. It also indicates that much of the delignification occurs in less than a minute in the mixer. It may be in 10-15 seconds or less. Most will occur in a few minutes in the mixer and the outlet pipe immediately after the mixer.

The maximum pressure in a mixer would normally not exceed 830 kPa gage, and the pressure at the top of the pipe if a hydrostatic leg is used would normally not exceed 345 kPa gage.

The mixer has also been operated under a hydrostatic pressure only.

The oxygen systems of Figs. 4, 5 and 6 are shown in a bleaching system in Fig. 7. Fig. 7 shows the same overall system as Fig. 1 and the same reference numerals are used throughout these figures. The system shown in Fig. 1 includes digestion of the wood chips in either a batch or continuous digester, brownstock washing, screening, dewatering in decker 121 and a D_CEDED bleach sequence. Fig. 7 shows digestion, brownstock washing, screening, and an OOCOD bleach sequence. For the most part, the operating conditions - time, temperature, pH, consistency and chemical addition - are the same in Fig. 7 as they were in Fig. 1.

The differences between the system in Fig. 7 and that in Fig. 1 is indicated by brackets at the bottom of Fig. 7.

The first difference between the process shown in Fig. 7 and that shown in Fig. 1 is indicated by bracket 430. This is the washer oxygen system of Fig. 5 and the reference numerals and operating conditions for this oxygen stage are the same as that given for the oxygen stage in Fig. 5. Since an oxygen treatment stage should have washed pulp, the oxygen stage 430 in Fig. 5 is shown after the third brownstock washer to indicate its placement after a batch digester in which no washing would occur in the digester. With a continuous digester, there would be fewer brownstock washers, and the oxygen stage could be earlier in the brownstock system.

The next change is shown by bracket 431. This is a modification of the washer oxygen system of Fig. 6. There should be at least two stages of washing after an oxygen bleach stage. The two washing stages after the oxygen stage at bracket 430 are washer 91''' and decker 121' which is converted to a washer. If the oxygen stage at bracket 430 had been after the second brownstock washer 51' rather than the third brownstock washer 71", then the oxygen system 431 could have been between washer 91''' and storage tank 110" as shown in Fig. 6.

In the system shown, the decker 121' has been converted to a washer by the addition of washer heads 125, a process water line 127 and a clean-up washer 124. The system has been further modified into an oxygen system by the addition of an alkali line 425, a steam mixer 426, a steam line 427, an oxygen mixer 428 and an oxygen line 429. These are placed between the decker 121' and the high-density storage tank 140'. The operation is the same as that described for Fig. 6.

The next change is at bracket 432. This shows, in dotted line, the elimination of the chlorine and chlorine dioxide equipment. The chlorine dioxide mixer 144', the chlorine dioxide tower 146', the chlorine aspirator 153', the chlorine mixer 155', the chlorine tower 157', and the pump 159' are eliminated. The piping and chemicals associated with this equipment are also eliminated.

The next change is at bracket 433. This bracket indicates the elimination of the extraction equipment between washers 161' and 181' so that these washers may be used as the two stages of washing after the oxygen stage at bracket 431. This is also indicated by the elements in dotted line. The eliminated items are the steam mixer 166', the extraction tower 173', and the pumps 170', 176', 278' and 282'. Again, the piping and chemical additions required by an extraction stage are also eliminated. The pump 170' may be retained to move the pulp 163' to washer 181' if this is necessary.

The next two changes are shown by brackets 434 and 435. Bracket 434 indicates the elimination of the chlorine dioxide stage and bracket 435 its replacement by a chlorine mixer. The elimination of the chlorine dioxide stage results in the elimination of steam mixer 186', chlorine dioxide mixer 191', chlorine dioxide tower 193', and pumps 190', 196', 298" and 302", their associated piping and chemicals. These are replaced by a small chlorine mixer 438 and the chlorine supply line 151'. A chlorine tower is not required. The pump 190' may be retained if it is required to move the pulp 183' to the mixer 430. The chlorine effluent in line 294" is maintained separate from the oxygen effluent.

The time in this mixer, as in the oxygen mixer, is less than 1 minute, and normally would be only a few seconds. Pulp traveling at 18.3 meters per second would pass through an 2.4 or 3 meter long reactor in an exceedingly short time. The chlorine would be treated at the temperature of the pulp off the washer, 54 to 60°C, rather than the cooler chlorination temperature.

The last change is shown by bracket 436. This is the oxygen addition to an extraction stage as shown in Fig. 4. The reference numerals and operating conditions are again the same as in Fig. 4.

Each of the gas mixers should be under a back pressure as described earlier.

Fig. 8 shows another arrangement in which the bleach sequence is OCODED. Again, the changes between Fig. 8 and Fig. 1 are shown by the brackets in Fig. 8. Changes 431'-436' are the same as those shown in Fig. 7. The same reference numerals and operating conditions are used in Figs. 1, 7 and 8.

There is one other change indicated by bracket 437. This is the addition of E and D stages at the end of process. Again, the process conditions for this last extraction stage are the same as those for the other extraction stages and for this last chlorine dioxide stage are the same as those for the other chlorine dioxide stages. It should also be realized that the only additional equipment required for these two stages are the two additional washers. The extraction equipment that was eliminated at 433' can be used in this extraction stage and the chlorine dioxide equipment eliminated at 434' can be used in this chlorine dioxide stage. In an actual modification, this equipment would be left in place and repiped.

For the purposes of the present description, however, new reference numerals will be used for these last stages.

In the E stage, the steam mixer is 446, the alkali line 447, the steam line 448, the slurry line 449, the pump 450, the extraction tower 453, the dilution zone 454, the line from the tower to the washer 455 and the pump 456.

In the extraction washer, the vat is 460, the washer 461, the drum 462, the exiting pulp 463, the cleanup washer 464, the incoming process water 490, the washer heads 491, the filtrate line 492, the seal tank 493, the effluent line 494, the dilution lines 495, 497 and 501 and their respective pumps 496, 498 and 502, and the counterflow wash water line 503 and its pump 504.

In the last chlorine dioxide stage, the steam mixer is 466, the alkali line 467, the steam line 468, the pulp slurry line 469, the pump 470, the chlorine dioxide mixer 471, the chlorine dioxide line 472, the chlorine dioxide tower 473, the dilution zone 474, the line from the tower to the washer 475, its pump 476, and the sulfur dioxide lines 477 and 478.

In the last washer, the vat is 480, the washer 481, the drum 482, the exiting pulp 483, the cleanup washer 484, the incoming process water 510, the washer heads 511, the filtrate line 512, the seal tank 513, the effluent line 514, the dilution lines 515, 517 and 521 and their pumps 516, 518 and 522, and the counterflow wash line 523 and its pump 524.

Again, each of the gas mixers should be under a back pressure, as described earlier.

These illustrate OCO sequences, and are exemplary of O-X-O sequences in general. In either sequence X may be chlorine, chlorine dioxide, a combination of chlorine or chlorine dioxide - C_D, D_C or a mixture of chlorine and chlorine dioxide, hypochlorites, peroxides or ozone. The mixers to be described may be used to mix these. The pulp may be treated with ozone by the treatment described in United States Patent Application serial number 836,449 filed September 26, 1977 or United States Patent Application serial number 2,491 dated January 11, 1979.

The amount of oxygen and the chemical used will depend, of course, on the K number of the unbleached pulp, the desired brightness and the number of bleach stages. As an example, an OOCOD sequence might use 14 to 20 kilograms of oxygen and 22 to 28 kilograms of sodium hydroxide per metric ton of oven-dry pulp in the first stage; 11 to 17 kilograms of oxygen and 17 to 22 kilograms of sodium hydroxide per metric ton of oven-dry pulp in the second stage; around 56 kilograms of chlorine per metric ton of oven-dry pulp in the third stage; 8 to 11 kilograms of oxygen per metric ton of oven-dry pulp in the fourth stage; and 14 to 16 kilograms of chlorine dioxide per metric ton of oven-dry pulp in the last stage. The temperature of the pulp would not be changed from the temperature of the washer for the chlorine treatment.

The remaining figures show several types of mixer that may be used with these systems. The exterior is the same in each; however, the internal structure does change.

In Figs. 9-12, the mixer 550 has a cylindrical body 551 and two head plates 552 and 553. The pulp slurry enters through pipe 554, passes through the body of the mixer and exits through pipe 555. The oxygen manifolds 558, which supply oxygen to the stators 580 within the mixer, are supplied by oxygen lines 559.

A shaft 560 extends longitudinally of the mixer and is supported on bearings 561 and 562 and is rotated by rotational means 563. A chain belt drive is shown, but any other type of rotational means may be used.

Rotors 570 are attached to the shaft 560. A typical rotor construction is shown in Figs. 13-14. The rotor 570 has a body 571 which is tapered outwardly from the shaft and has an elliptically generated cross

section. The preferred cross section is an ellipse. The major axis of the rotor is aligned with the direction of rotation of the rotor. Each of its leading and trailing edges 572 and 573 has a radius of the curvature in the range of 0.5 to 15 mm. The radii are usually the same, though they need not be. If different, then the leading edge would have a greater radius than the trailing edge.

A modification is shown in Figs. 15-16. A groove 574 is formed in the trailing edge 573' of the rotor. The groove is about 0.1 mm across. The groove may be coated with a hydrophobic material.

The number of rotors and the speed of the rotors will depend on the amount of pulp passing through the mixer and the consistency of the pulp passing through the mixer. The area swept by the rotors should be in the range of 10,000 to 1,000,000 square meters per metric ton of oven-dry pulp. The preferred range is 25,000 to 150,000 square meters per metric ton of oven-dry pulp. The optimum is considered to be around 65,400 square meters per metric ton of oven-dry pulp. This area is determined by the formula

$$A = \frac{1440\,\pi\,(r_1^2 - r_2^2)\,(R)(N)}{t}$$

where

A	=	area swept per metric ton, m^2/t
r_1	=	outer radius of the rotor, m
r_2	=	inner radius of the rotor, m
R	=	revolutions per minute of the rotor
N	=	number of rotors
t	=	metric tons (Oven-Dry Basis) of pulp passing through the mixer per day.

There is a trade-off between the length of the individual rotors and the number of rotors. The rotors are usually arranged in rings on the central shaft. The number of rotors in a ring will depend upon the circumference of the central shaft and the size of the rotor base. A greater number of rotors would require a longer and stiffer shaft. Fewer rotors would require longer rotors. Consequently, space for the mixer would determine the actual rotor configuration. Normally, there are a total of 4 to 400 rotors, and from 2 to 20 rotors in a ring.

The rotors rotate transversely of the direction of pulp movement through the mixer, describing a helical path through the pulp. The speed of

rotation of the rotors would be determined by the motor, and the drive ratio between the motor and the central shaft.

The diameter of the central shaft 560 is at least one half of the internal diameter of the mixer, forming an annular space 568 through which the slurry passes.

The enlarged shaft requires scraper bars 564 and 565 on shaft ends 566 and 567. There normally would be four bars on each end. The bars remove fibers that tend to build up between the shaft and the mixer head plate. This prevents binding of the shaft in the mixer.

The stators are shown in Figs. 17-19. The stators add oxygen to the pulp in the mixing zone and also act as friction devices to reduce or stop the rotation of the pulp with the rotors so that there is relative rotative movement between the rotors and the pulp. Each stator 580 has a body 581, a central passage 582 and a base plate 583. The stators extend through apertures 556 in body 551. There are two ways of attaching the stators. In Fig. 17, the stator is attached to the body 551 by a friction fit using a Van Stone flange 584. This allows the stator to be rotated if it is desired to change the oxygen placement. In Fig. 18, the base plate 583' is attached directly to the body 551 either by bolts or studs. The oxygen enters the mixer through check valves 590. The stators are round and tapered and the face having the check valves is flattened. The check valves face across a transverse plane of the mixer and in the direction of rotation of the rotors.

The purpose of the check valve 590 is to prevent the pulp fibers from entering the passage 582. A typical check valve is shown in Fig. 20. The valve 590 consists of a valve body 591 which is threaded into stator body 581. The valve body has a valve seat 592. The valve itself consists of a bolt 593 and nut 594 which are biased into a closed position by spring 595.

The number of check valves in a stator may vary from 0 to 4. In some mixers, the major portion of the gas would be added at the mixer entrance, requiring up to 4 check valves, and little or no gas would be added near the mixer outlet, requiring 1 check valve or no check valves, and the stators would then only act as friction drag against pulp rotation. For example, between 60 to 70% of the oxygen could be added in the first half of the mixer. The first one third of the stators would have 3 or 4 check valves, the next one third might have 2 check valves, and the last one third might have 1 or no check valves.

The stators may also be arranged in rings. There being one ring of stators for each one or two rings of rotors. The number of stators in a ring will depend upon the size of the mixer. Usually, there are 4 stators in a ring, but this can normally vary from 2 to 8.

Both the rotors and the stators should extend across the annular space. A normal clearance between the rotor and the inner wall of the mixer, or the stator and the outer wall of the central shaft is about 13 mm. This ensures that all of the pulp is contacted by the oxygen and there is no short circuiting of the pulp through the mixer without contact with oxygen. The rotors and stators should be between the inlet and outlet to ensure that all the pulp would pass through the swept area, and would be contacted with oxygen.

Figs. 21-26 disclose a modification to the basic mixer. Oxygen is carried to the rotors through pipe 600 and passage 601 which extends centrally of shaft 560'. Radial passages 602 carry the oxygen to the outer annular manifold 603. The oxygen passes from the manifold to the pulp through central passage 604 of rotor body 605 and through check valve 590". These valves are the same as valve 590.

The rotor is shown as round and tapered, but its shape may be different. The rotor may be round or square and nontapered such as those normally found in steam mixers. The round rotors would have radii of curvature exceeding 30 mm. Tapered rotors 606 having a rectangular cross section may also be used.

Fig. 27 compares the operation of a modified mixer similar to that shown in Figs. 21-26 with the operation of the mixer of Figs. 9-20 and indicates the increasing efficacy of the mixer as the swept area is increased and the shaft diameter is expanded. The casing of both mixers was the same. It had an interior diameter of 0.914 m. The inlet and the outlet were the same. In both, the outer radius of the rotor was the same, 0.444 m. Both processed pulp at the same rate, 810 metric tons of oven-dry pulp per day.

The modified mixer had a speed of rotation of 435 RPM. There were 32 stators in 8 rings and 36 rotors in 9 rings. Each ring of rotors had 2 pegs and 2 blades. The blades were rectangular in cross section. The stators and rotor pegs were round, tapered outwardly and 0.254 m long. Oxygen was admitted through the stators only. The diameter of the shaft

was 0.38 m and the swept area was 14,100 square meters per metric ton of oven-dry pulp.

The mixer of Figs. 9-20 had the same internal diameter but had a central shaft that was 0.508 m in diameter. There were 224 rotors. The rotors were elliptical and linealy tapered. The major axis of the rotor extended in the direction of rotation of the rotor. The leading and trailing edges of the rotor had radii of curvature of 3.8 mm. The rotors were 19 cm long and extended to within about 13 mm of the reactor wall, and the stators extended to within about 13 mm of the central shaft. The speed of rotation of the rotors was 435 RPM. The swept area of the reactor was 72,200 square meters per metric ton of oven-dry pulp. Oxygen was admitted through the stators.

Fig. 23 compares the extracted K number of the pulp with the additional K number drop after passing through the mixer, and shows that the mixer achieved a greater K number drop than the modified mixer. It was also found that the mixer needed only half the amount of oxygen as in the modified mixer to obtain the same amount of delignification; that is, with the other operating conditions remaining the same, to achieve the same K number drop, 11 kilograms of oxygen per metric ton of oven-dry pulp were required in the modified mixer, but only 5 kilograms of oxygen per metric ton of oven-dry pulp were required in the mixer. It was also found that the mixer could mix greater amounts of oxygen with the pulp than the modified mixer. Between 1-1/2 to 2 times as much oxygen could be mixed with the pulp with the mixer than with the modified mixer. For example, the modified mixer could mix a maximum of 15.1-20.2 kilograms of oxygen with a metric ton of oven-dry pulp. The mixer could mix 30.2-35.3 kilograms of oxygen with a metric ton of oven-dry pulp.

The optimum swept area is achieved by reducing the number of rotors in the mixer from 224 to 203.

Figs. 28-30 illustrate a different type of rotor and stator arrangement and a different type of oxygen admission.

In this modification, an oxygen manifold 610 surrounds the outer body 551" of the mixer and the gas enters the mixer through holes 611 in body 551". An annular dam 612, located between each ring of holes 611, is attached to the inner wall of body 551". The dams 612 create a pool of gas adjacent the mixer wall. The stators 585 are attached to the dams 612. The

rotors 575 are aligned with the spaces between the dams 612. The outer radius of the rotors 575 is greater than the inner radius of the dams 612 so that the rotors extend beyond the inner wall 608 of the dam into the trapped gas between the dams. This construction allows the rotor to extend into a gas pocket and for the gas to flow down the trailing edge of the rotor as it passes through the pulp slurry.

The rotors and stators may be flat with rounded leading and trailing edges. Again, the radius of curvature of the leading and trailing edges would be in the range of 0.5 to 15 mm, and the radii need not be the same. The rotors and stators may be as narrow as 6.35 mm in width.

This design could also include the groove in the trailing edge of the rotor which may be covered with a hydrophobic coating.

CLAIMS

What is claimed is:

1. The process of bleaching wood pulp comprising

treating pulp having a consistency of 7 to 15% with oxygen at an alkaline pH and a temperature of around 65°C to around 121°C,

washing said pulp,

treating said pulp with a bleaching chemical selected from the group consisting of hypochlorites, peroxides and ozone,

washing said pulp, and

treating said pulp having a consistency of 7 to 15% with oxygen at an alkaline pH and a temperature of around 65 to around 121°C.

2. The process of claim 1 in which said first oxygen treatment is preceded by

treating said pulp at a consistency of 7 to 15% with oxygen at an alkaline pH and a temperature of around 65 to around 121°C, and

washing said pulp.

3. The process of claims 1 or 2 in which said last oxygen treatment is followed by

washing said pulp, and

treating said pulp with chlorine dioxide.

4. The process of bleaching wood pulp comprising treating pulp having a consistency of 7 to 15% with oxygen at an alkaline pH and a temperature of around 65°C to around 121°C,

washing said oxygen treated pulp,

treating said washed pulp with a bleaching chemical selected from the group consisting of chlorine, chlorine dioxide, combinations of chlorine and chlorine dioxide, hypochlorites, peroxides and ozone,

washing said latter bleached pulp, and

treating said latter washed pulp having a consistency of 7 to 15% with oxygen at an alkaline pH and a temperature of around 65 to around 121°C.

5. The process of claim 1 in which said first oxygen treatment is preceded by

treating said pulp at a consistency of 7 to 15% with oxygen at an alkaline pH and a temperature of around 65 to around 121°C, and

washing said preceding oxygen treated pulp.

6. The process of claims 1 to 2 in which said last oxygen treatment is followed by

washing said pulp, and

treating said washed pulp with chlorine dioxide.

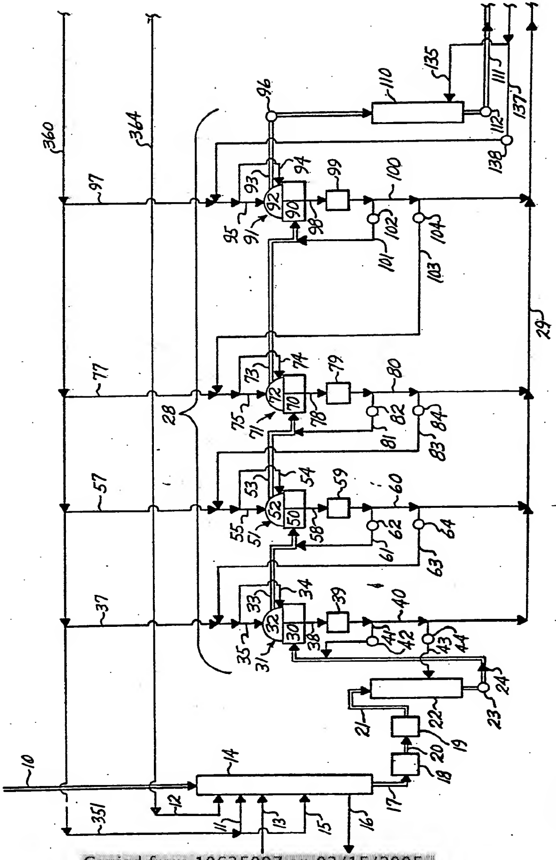

Fig. 1A PRIOR ART

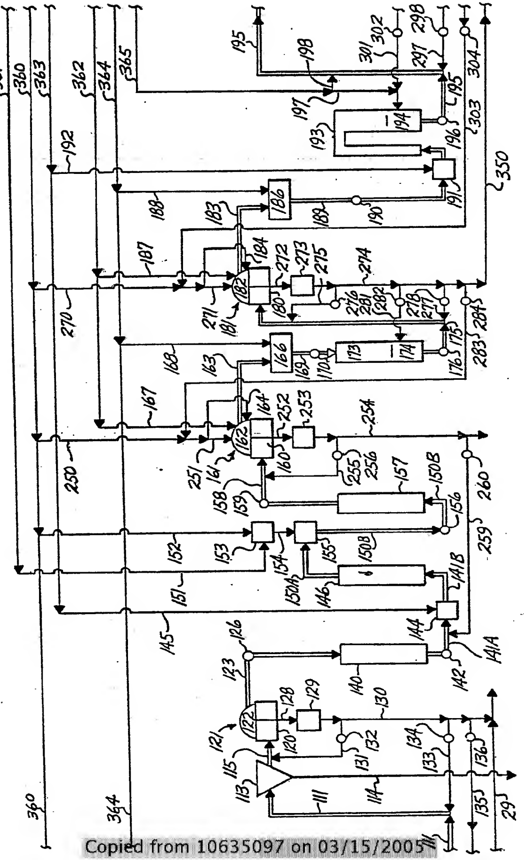

Fig.1B PRIOR ART

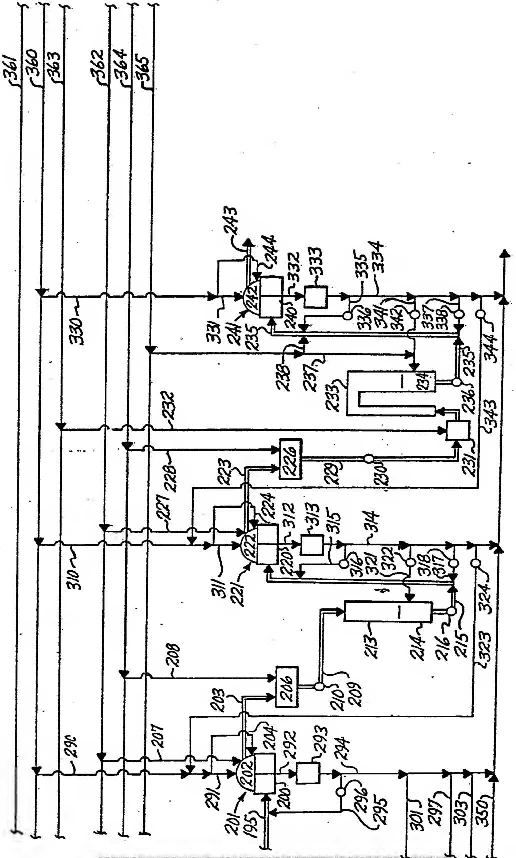

Fig. 1C
PRIOR ART

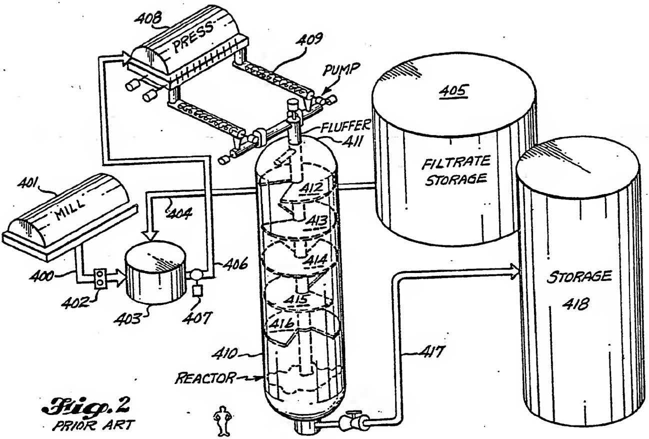

Fig. 2
PRIOR ART

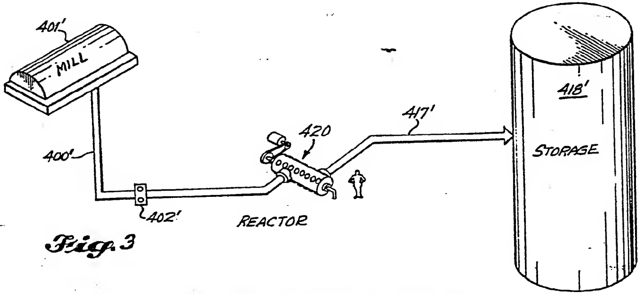

Fig. 3

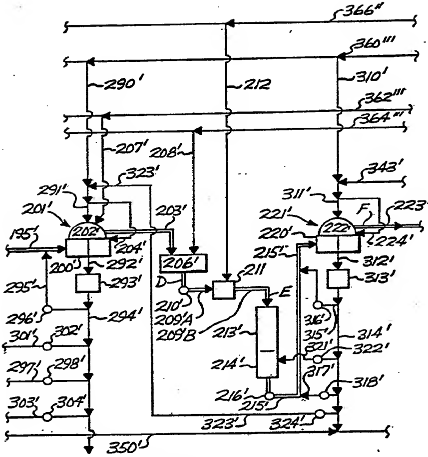
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Fig. 4

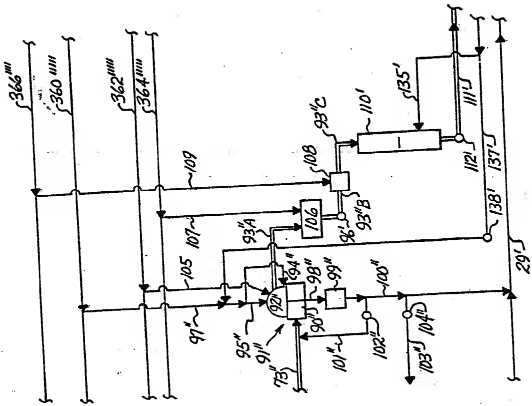

Fig. 6

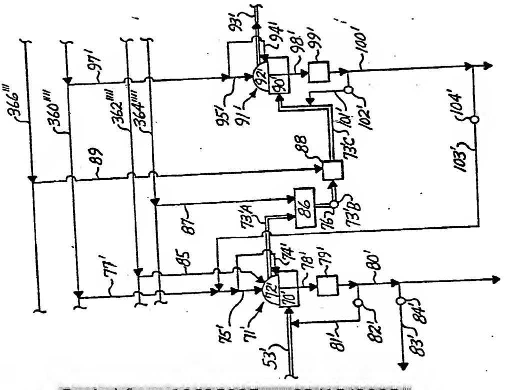

Fig. 5

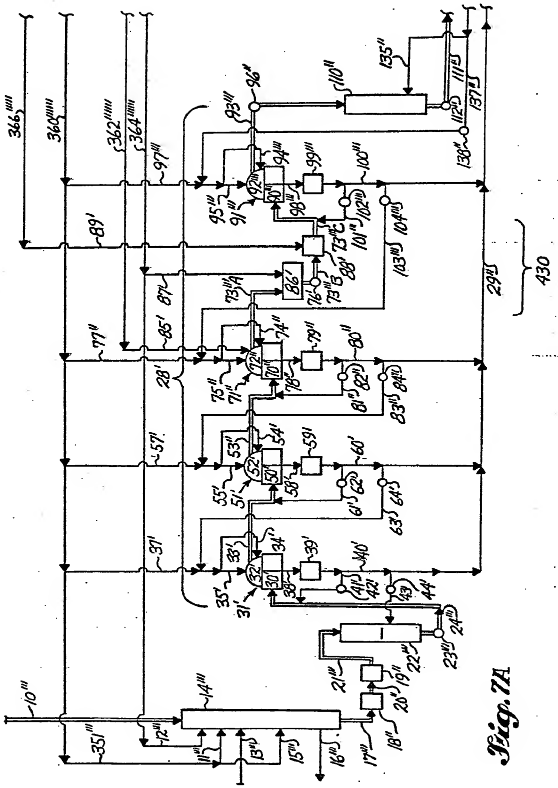

Fig. 7A

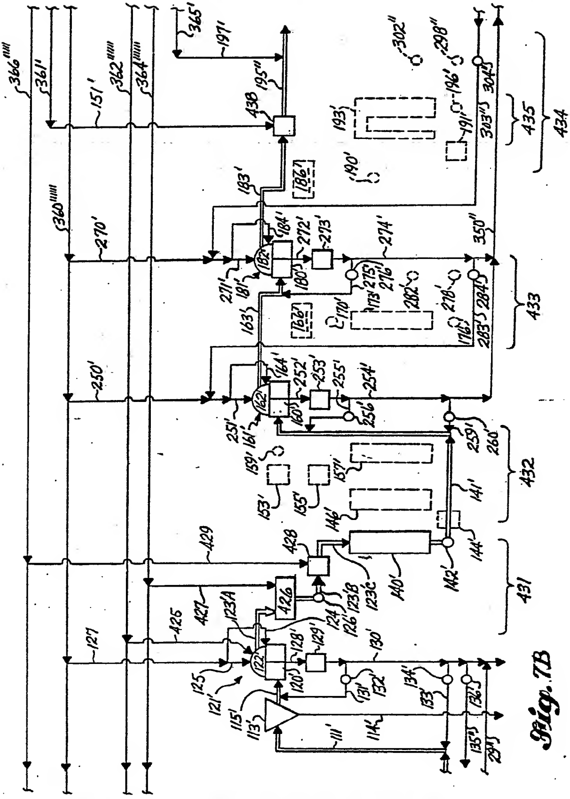

Fig. 7B

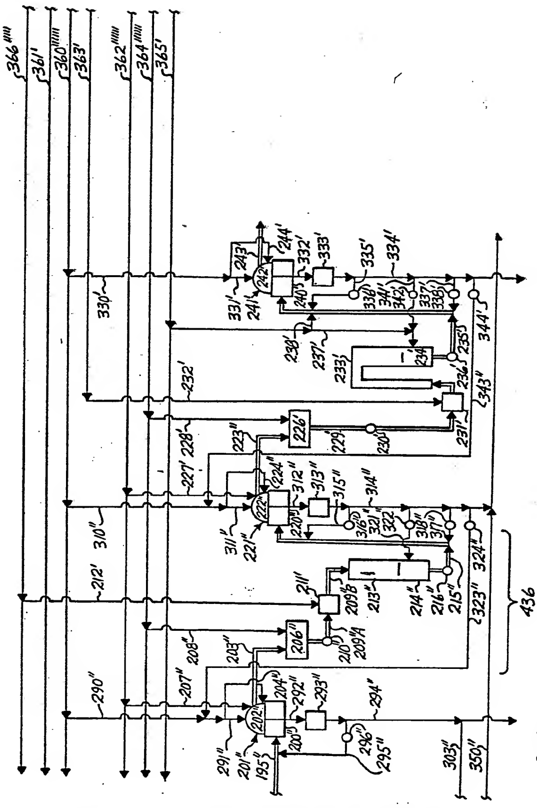
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Fig. 7C

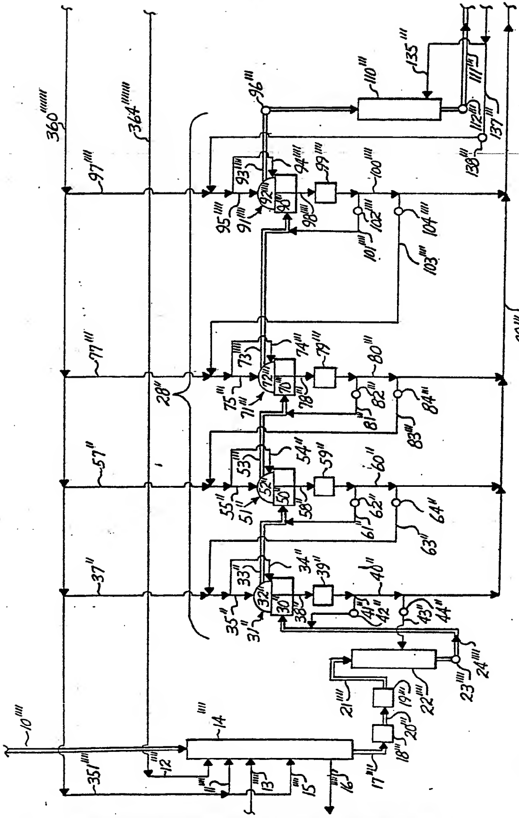

Fig. 8A

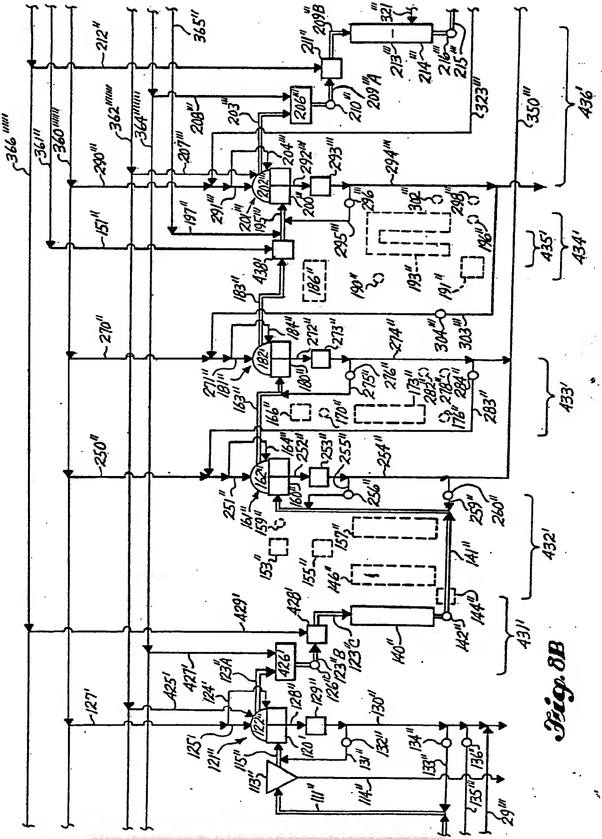

Fig. 8B

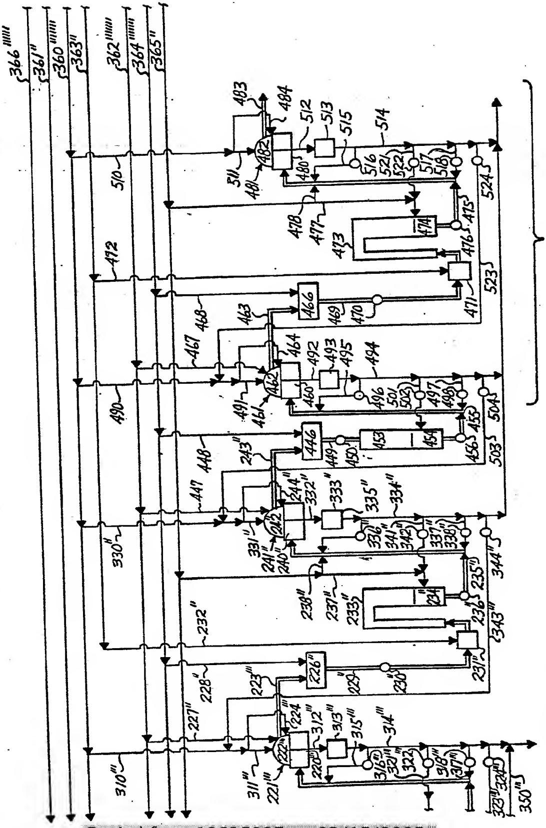

Fig. 8C

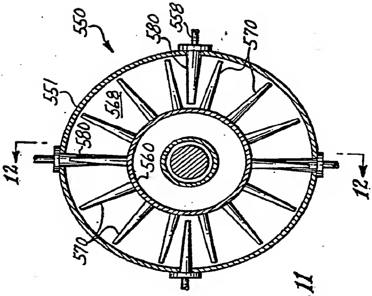
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Fig. 11

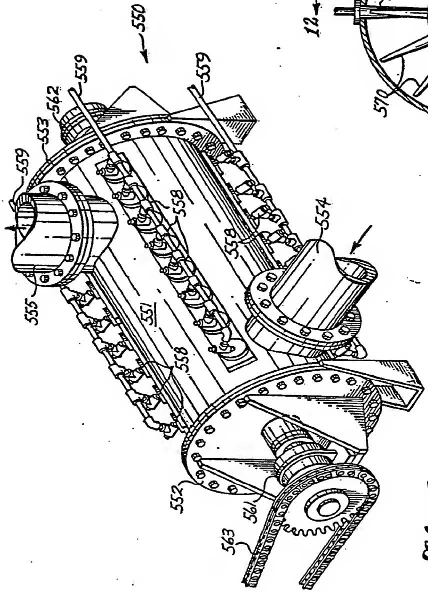
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Fig. 9

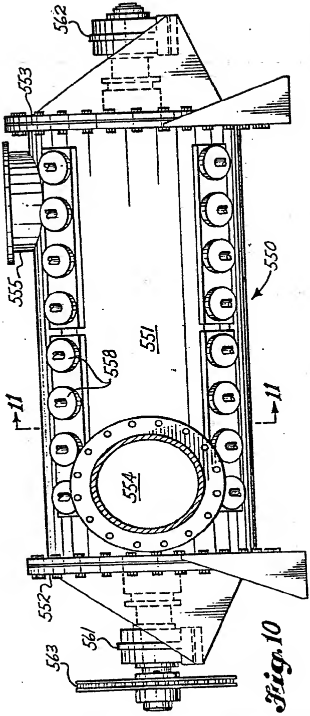
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Fig. 10

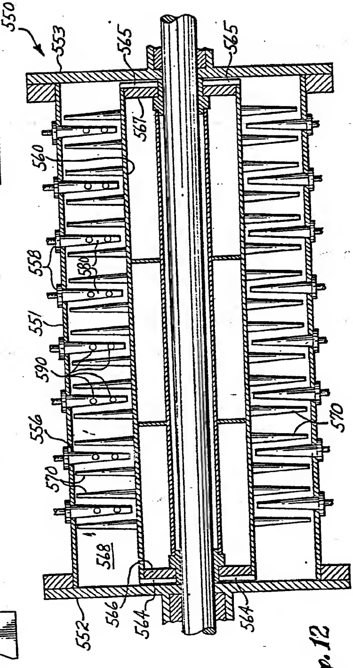
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Fig. 12

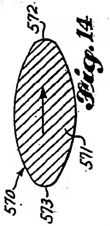

Fig. 14

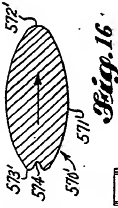

Fig. 16

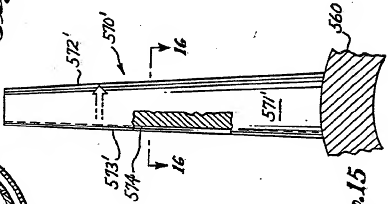

Fig. 15

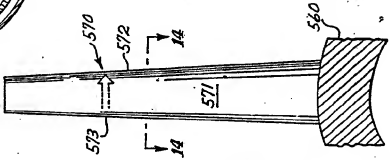

Fig. 13

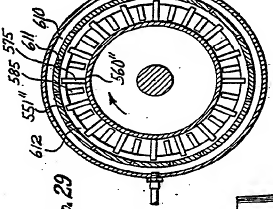

Fig. 29

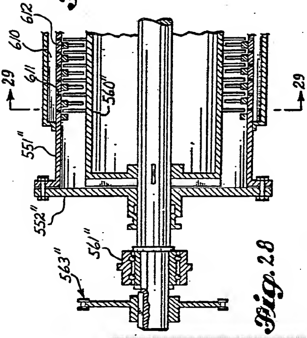

Fig. 28

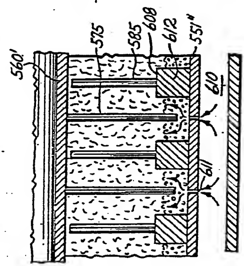

Fig. 30

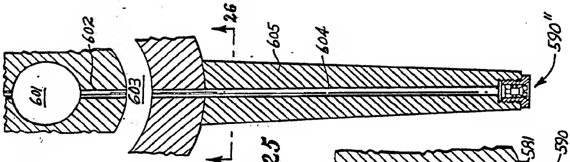

Fig. 25

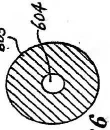

Fig. 26

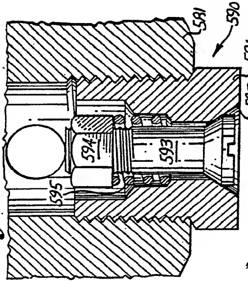

Fig. 20

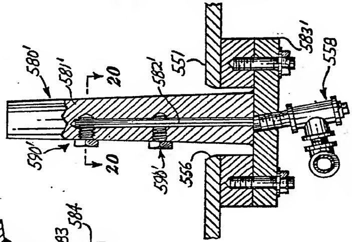

Fig. 18

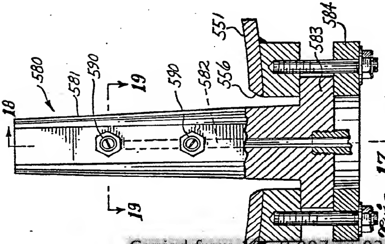

Fig. 17

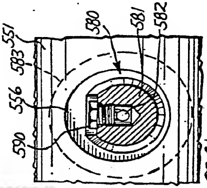

Fig. 19

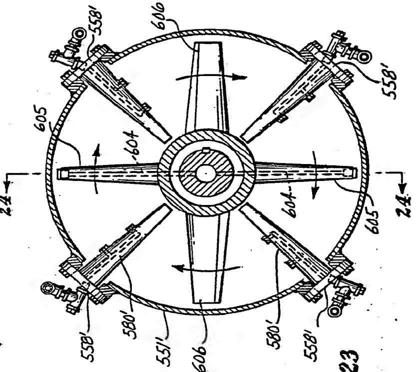
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Fig. 23

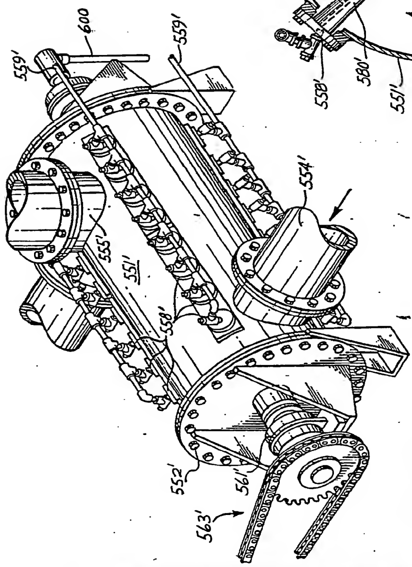
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Fig. 21

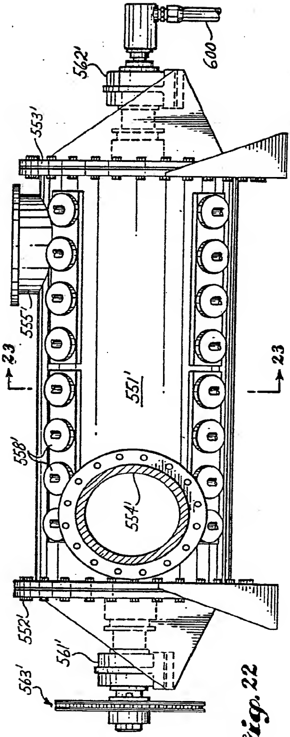
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Fig. 22

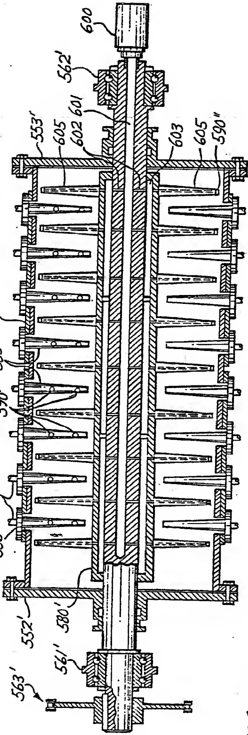
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Fig. 24

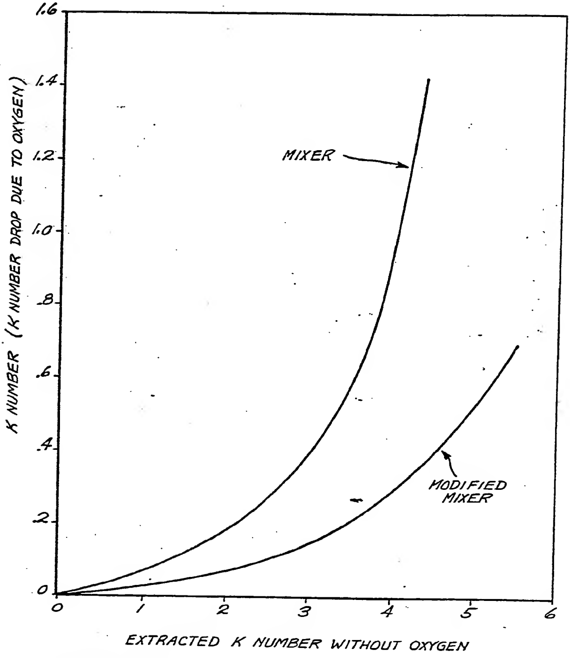
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
K NUMBER (K NUMBER DROP DUE TO OXYGEN)
MIXER
MODIFIED MIXER
0
1
2
3
4
5
6
EXTRACTED K NUMBER WITHOUT OXYGEN

Fig. 27

INTERNATIONAL SEARCH REPORT

International Application No PCT/US81/01186

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.[3] D21C 9/02,10,14,16

U.S. CL. 162/57,60,65,78,88,89,

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	8/109,149/1,156; 68/5B,5C,5D,181R,183; 162/23,24,57,60,65,78,88,89,243; 366/102,103,104,157,167,178

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	N, THE PRESENT AND FUTURE ROLE OF OXYGEN BLEACHING, A. JAMIESON, M.D. INTERNATIONAL SERVICES.	1-6
A	N, TAPPI, VOLUME 59, NUMBER 11, ISSUED NOVEMBER 1976, KLEPPE ET AL, OXYGEN/ALKALI DELIGNIFICATION OF KAMYR DIGESTER BLOWLINE CONSISTENCY, SEE PAGES 77-80.	2,4
A	N, PULP AND PAPER MAGAZINE OF CANADA, VOLUME 25, NUMBER 4, ISSUED APRIL 1924, SOTELAND, BLEACHING OF CHEMICAL PULPS WITH OXYGEN AND OZONE.	2,4
A	US,A, 3,832,276, PUBLISHED 27 AUGUST 1974, ROYMOULIK ET AL.	1-6
A	US,A, 4,161,421, PUBLISHED 17 JULY 1979, SHERMAN.	1-6

* Special categories of cited documents: [15]

"A" document defining the general state of the art

"E" earlier document but published on or after the international filing date

"L" document cited for special reason other than those referred to in the other categories

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
07 OCTOBER 1981	30 OCT 1981
International Searching Authority [1]	**Signature of Authorized Officer [10]**
ISA/US	Steve Alvo MARC STEVEN ALVO